11 CSR 50-2.406 Technical Specifications for the MAS

(1) General. The Missouri analyzer system (MAS) shall be compatible with all types of automotive service operating environments. The analyzer shall operate under the conditions and performance requirements listed here.

(2) Automatic Zero and Span. The analyzer shall conduct an automatic zero and span check (or equivalent, with state approval) prior to each test. The span check shall include the HC, CO and CO_2 channels (and optional O_2).

(3) Zero Drift Lockout Threshold. If zero and/or span drift cause the infrared signal levels to move beyond the adjustment range of the analyzer, the operator shall be locked out from performing emission inspections and instructed to call for service. The analyzer manufacturer shall indicate, in writing, at what point the drift lockout will occur.

(4) Gas Calibration and Leak Check.

(A) The analyzer, to the maximum extent possible, shall maintain accuracy between gas calibrations taking into account all errors (including noise, repeatability, drift, linearity, temperature and barometric pressure.) The analyzer shall automatically require and successfully pass a gas calibration for HC, CO and CO_2 (and on the optional O_2 if purchased) by a method that is approved by the state at least every three (3) days or the analyzer shall lock itself out from further state emission inspections. The gas calibration shall ensure that accuracy specifications are satisfied and that linearity is correct at both of the required span points or the analyzer shall be automatically prohibited from performing any portion of the state emission inspections. The gas calibration procedure shall correct the readings to the center of the allowable tolerance range. Manufacturers shall include an evaluation of this capability, consisting of at least five (5) analyzers, with their certification application materials and shall demonstrate this feature during certification.

(B) Gas Calibration shall be accomplished by introducing National Institute of Standards and Technology (NIST) traceable gases into the analyzer either through the calibration port or through the calibration port or through the probe. Span gases utilized for calibration shall be within two percent (2%) of the required span points.

(C) The gas calibration and leak check procedures shall require no more than five (5) minutes. The analyzer shall provide adequate prompts on the display to guide the inspector mechanic through the calibration procedure in a manner that minimizes the amount of gas used. The analyzer shall be designed

to keep the loss of calibration gas to an absolute minimum (less than 0.5 liters in twenty-four (24) hours) if the inspector mechanic forgets to shut the valve off.

(D) Alternate gas calibration systems, used in lieu of introducing gas at the specified span points, will be considered by the state, but will be required to meet additional requirements that will be specified in the MAS certification test procedures. At least, alternate gas calibration systems or procedures shall compensate for the following items:

1. Optical bench temperature and ambient barometric pressure shifts;

2. The effects of ambient air contamination on span and linearity;

3. The effects of the buildup of organic matter on optical windows on span and linearity;

4. The effects of changes in the sample cell wall reflections on linearity;

5. The effects of the angle of incidence on the optical filter on center frequency and the bandwidth;

6. Optical settling effects resulting from benches passing through thermal transients; and

7. Aging of the source. The state feels strongly that the only sure way to compensate for these effects is to perform frequent gas calibrations using gases in the spectral range of at least the two (2) required span points.

(E) Proposals for less frequent gas calibrations will be subjected to lengthy accuracy and drift tests. Proposals of this type shall be thoroughly evaluated (for example, lab as well as field testing in the range of the required span points for accuracy and drift for extended periods of time) and characterized prior to submission to the state.

(5) Propane Equivalency Factor (PEF). The PEF shall be conveniently displayed on the MAS for the State Highway Patrol (SHP) representatives in a manner acceptable to the state. All emission analyzers which have the PEF changed must be affixed with the proper PEF information in the same manner as the original PEF before inspections are resumed.

(6) Nondispersive Infrared Beam Strength. The beam strength

from the source to the detector for all channels shall be monitored so that when the beam degrades beyond the adjustment range of the analyzer, the analyzer shall be locked out from operation. The manufacturer shall specify at what point degradation occurs where the signal cannot be corrected.

(7) Date of Last Gas Calibration. The date of the last gas span shall be kept in nonvolatile memory (or on the hard disk) and shall be displayed on the Status Screen in the Motor Vehicle Inspection (MVI) State Audit Menu.

(8) Lockout Criteria. If the MAS has not successfully passed a gas calibration and a leak check for a period of three (3) days or more, it shall lock itself out from performing an official state emissions inspection and display a message to the operator upon startup.

(9) Audit Gas Pressure. During a gas audit, analyzer readings shall not change by more than one percent (1%) if the audit gas pressure is modified by plus or minus 1.5 pounds per square inch (psi) from one (1) atmosphere of pressure at the probe.

(10) Calibration and Leak Check gas Usage. For HC, CO and CO_2, analyzer manufacturers shall limit gas usage during the gas calibration procedure to two (2) liters per span point or demonstrate to the satisfaction of the state that a greater amount must be utilized to properly calibrate their instrument and that it would be cost prohibitive to reduce it to acceptable levels. An additional two (2) liters may be used to perform the leak check.

(11) Span Points. A two (2)-point gas calibration procedure shall be followed by all manufacturers.

(A) The span shall be accomplished at the following points:

1. 300ppm propane;

A. 1.0% carbon monoxide;
B. 6.0% carbon dioxide; and
C. 20.9% oxygen (if equipped with O_2); and

2. 1200ppm propane;

A. 4.0% carbon monoxide; and
B. 12.0% carbon dioxide

(B) Ambient air may be used to calibrate the O_2 sensor.

(12) Accuracy Tolerances.

(A) The analyzer shall meet the following accuracy requirements:

Channel	Range	Accuracy	Noise	Repeatability
HC.ppm	0))400	±12	6	8
	401))1000	±30	10	15
	1001))2000	±80	20	30
CO,%	0))2.00	±0.06	0.02	0.03
	2.01))5.00	±0.15	0.06	0.08
	5.01))9.99	±0.40	0.10	0.15
CO_2,%	0))4.0	±0.6	0.2	0.3
	4.1))14.0	±0.5	0.2	0.3
	14.1))16.0	±0.6	0.2	0.3
O_2,%	0))10.0	±0.5	0.3	0.4
O_2,%	10.1))25.0	±1.3	0.6	1.0

(B) Rounding beyond the decimal places shown in the table shall follow the standard mathematical practice of going to next higher number for any numerical value of five (5) or more. Only numerical values more than three (3) places behind the decimal may be truncated.

(13) Analyzer Display.

(A) The analyzer electronics shall have sufficient resolution and accuracy to achieve the following:

HC	1	PPM HC
CO	0.01	%CO
CO_2	0.1	%CO_2
O_2	1	%O_2 (optional)
RPM	1	RPM

(B) Dynamic information being displayed shall be refreshed at a minimum of twice per second.

(14) System Response Time Requirements for Analyzer Channels. The response time from the probe to the display shall not exceed

eight (8) seconds to ninety percent (90%) of a step change in input. If an analyzer is equipped with a optional O_2 sensor, the response time for the O_2 sensor may be as long as fifteen (15) seconds to ninety percent (90%) of full scale.

(15) Environment Operating Range.

(A) Temperature. The analyzer, including all of the software/hardware enclosed in the cabinet, shall operate within the performance specifications described in this rule in ambient air temperatures ranging from forty-one to one hundred ten degrees Fahrenheit (41-110°F). The state will attempt to stimulate, as closely as possible, actual diurnal and seasonal temperature changes which might be experienced by the stations to evaluate this performance requirement. Analyzers must be designed so that adequate air flow is provided around critical components to prevent overheating (and automatic shutdown) and to prevent the condensation of water vapor which could reduce the reliability and durability of the analyzer.

(B) Humidity. The analyzer, including all of the software/hardware enclosed in the cabinet, shall operate within the performance specifications described in this rule at up to eighty percent (80%) relative humidity throughout the required temperature range.

(C) Interference Effects. The interference effects from noninterest gases shall not exceed ± ten (10) PPM for hydrocarbons, ± 0.05 percent for carbon monoxide and ± 0.20 percent for carbon dioxide.

(16) Power/Telephone Cord.

(A) The telephone line, separated from the power cord, shall be provided for the modem. The telephone line shall be enclosed in a protective cable meeting state and Underwriters' Laboratory (UL) or Environmental Testing Laboratory (ETL) approval. Alternative methods to protect the telephone line may be submitted to the state for approval. The manufacturer shall include provisions to ensure that the power necessary to activate the modem at the appropriate time is available.

(B) The telephone line shall be plugged in at the times specified by the state. If a dial tone is not found, or if inspection data is not transferred to the state at the specified time, an appropriate message shall be displayed the next time the power to the analyzer is turned on.

(C) The analyzer shall be supplied with a twenty-five foot (25') UL- or ETL-approved power cord. The manufacturer shall design the cabinet so that convenient storage is provided for any excess cord.

(17) Power Requirements.

(A) The MAS shall operate only on alternating current (AC). No direct current (DC) models will be acceptable. The MAS shall not be powered by a portable AC generating unit. An exception to this rule may be sought by the manufacturer if it can be shown, to the satisfaction of the state, that the analyzer is immune to the line frequency variations of the portable AC generating unit. Immunity to line frequency variations is defined here as line frequency variations which will not cause more than one percent (1%) of full scale (FS) disturbances on any one of the analyzers. Additionally, any AC portable generating unit used with the MAS shall not have frequency excursions exceeding one (1) hertz from sixty (60) hertz.

(B) Input power shall be one hundred fifteen volts (115 VAC), sixty hertz (60 Hz). All instruments shall meet the requirements contained in the MAS specifications, with an input voltage variation of no more than plus twelve (+12) volts. Maximum allowable performance change due to line voltage variations shall not exceed one percent (1%) of FS value.

(C) The analyzer shall have a main power switch located on the back panel with a power-off/standby mode switch on the front panel. The operator shall be instructed in the owner's manual to leave the main power switch on and the telephone line plugged in at all times unless the analyzer needs to be relocated or damage to the telephone line will result. The power-off/standby mode shall provide the power necessary for the telephone modem to remain in a standby condition.

(18) Warm Up Time and System Lockout.

(A) Warm Up. The analyzer shall reach stability within fifteen (15) minutes at forty-one degrees Fahrenheit (41°F) from startup. If an analyzer does not achieve stability within the allotted time frame, it shall be locked out from inspection/maintenance (I/M) testing and a message shall be displayed instructing the operator to call for service.

(B) System Lockout. Functional operation of the gas sampling unit shall remain disabled through a system lockout until the instrument meets stability and warm up requirements. The instrument shall be considered warmed-up when the zero and span readings for HC, CO and CO_2 have stabilized, within plus or minus three percent (± 3%) of the full range of low scale, for

five (5) minutes without adjustment. Evaluation of this feature will require demonstration of accuracy at both span point when the analyzer meets the warm up criteria.

(C) During warm up, the analyzer software shall check for mail from the state sent by telephone modem the night before. During the warm up, the main menu shall be displayed unless there is a message from the state or a maintenance message. If the operator selects any item from the main menu, a message shall be prominently displayed as follows: Warm up in progress-checking for stability.

(D) When stability is achieved and the warm up requirements are satisfied, access to programs shall be allowed.

(19) Instrument construction and Identification.

(A) Basic Construction. The instrument shall be designed and constructed to provide reliable and accurate service in the automotive repair environment. The analyzer shall be supplied with a cabinet which is equipped with a storage area large enough to secure all accessories and operating manuals.

(B) Materials. The materials used in instrument construction shall be resistant to corrosive type substances found in the automotive repair environment and be designed to last for at least the period of the warranty.

(C) Finish. The exterior and interior finish of the entire cabinet and console shall be sufficiently durable to withstand the chemicals and environmental conditions normally encountered in the automotive repair environment for the period of the warranty.

(D) Mobility. The analyzer may be permanently mounted or mobile with wheels, and shall meet UL Standard 1244 or applicable ETL Standard. If mobile, the analyzer shall be designed so that movement over rough surfaces (three-inch (3") deep holes) and on fifteen degree (15°) inclines, will not cause it to tip over. Wheels must be at least five inches (5") in diameter and have a locking mechanism capable of preventing movement on a fifteen degree (15°) incline. Analyzers shall remain upright when placed at the center of an inclined plane that makes an angle of ten degrees (10°) with the horizon and rotated three-hundred sixty degrees (360°). In addition, the analyzer shall remain stable and upright when rolled off a two-inch (2") high platform or when

one (1) wheel is rolled over a depression, two inches (2") below the surface and inside an eighteen-inch (18") diameter depression.

(E) Identification. The analyzer serial number, the date of production, the MAS number and the propane equivalency factor (PEF) shall be conveniently displayed on each analyzer in a manner meeting the state's approval. The left character of the MAS number shall be alpha denoting the manufacturers name and shall not be changed without written state authorization. The initial chosen is subject to approval by the state to prevent duplication between manufacturers. The remaining three (3) characters shall be numeric. The numbers shall be right justified. Zeroes shall be used to fill any blank spaces between the initials and the numerics. For example, the MAS number for analyzer 323 from Acme Electronics would be A323.

(F) Electrical Design. Provisions shall be made for storing the power cord in a manner satisfactory to the state. Fuses or circuit breakers shall be used to protect individual electrical circuits and emission analyzers. Breakers and fuses shall be readily accessible from the exterior of the cabinet. Analyzer operation shall be unaffected by electrical line noise and voltage surges. The analyzer shall be sufficiently protected from voltage surges to prevent damage to the analyzer from the simultaneous start up of a two hundred twenty (220) volt compressor, an arc welder, hydraulic controls and other equipment commonly found in the typical garage.

(G) Electromagnetic Isolation and Interference.

1. Electromagnetic signals found in an automotive environment shall not cause malfunctions or changes in accuracy in the electronics of the MAS. The instrument design shall insure that readings do not vary as a result of electromagnetic radiation and induction devices normally found in the garage environment (including high energy vehicle ignition systems, radio frequency (RF) transmission radiation sources and building electrical systems).

2. In addition, the manufacturer shall ensure that the analyzer processor and memory components are sufficiently protected to prevent the loss of programs and test records.

(H) Vibration and Shock Protection. System operation shall be unaffected by the vibration and shock encountered under the normal operating conditions encountered in an automotive

environment. Instruments, motors, pumps and disk drives shall be shock-mounted to absorb any vibration which might affect the system operation.

(20) Operator's Instruction Manual Storage. A drawer or enclosed cabinet with shelves shall be provided to store the analyzer operation instruction manual and the state Emission Inspection Manual. The operating manual shall include at least an overview of analyzer and software operation, emission inspection and test procedures, gas calibration procedures, leak check procedures and operator maintenance tips.

(21) Sampling System.

(A) The sampling system, at a minimum, shall consist of a tailpipe probe, flexible sample line, a water removal system, particulate trap, sample pump and flow control components. The sample system shall be designed to allow the addition of the necessary components to conduct loaded mode testing. The flexible sample line shall be at least twenty-five (25') long.

(B) The system shall be designed to insure durable, leak-free operation and be easily maintained. The operator's manual shall also indicate the capabilities of the particular system provided.

(C) Materials that are in contact with the gases sampled shall not contaminate or change the character of the gases to be analyzed. The sampling system shall be designed to be corrosion-resistant for at least five (5) years and be able to withstand typical vehicle exhaust temperatures. An optional probe and sampling system shall be available from the manufacturer and be capable of withstanding the higher temperatures associated with loaded mode testing.

(D) The sample hose shall be connected to the analyzer sample system with a screw-type fitting. The probe used to test vehicles with a single exhaust pipe shall be connected to the sample hose with a screw-type fitting which has a tee with a quick disconnect. The quick disconnect on the tee will allow the second probe to be easily attached for testing vehicles with dual exhaust. Quick disconnects will not be allowed on either the sample hose or the primary probe.

(E) Fittings and connectors used on the sample hose and probe shall be assembled in a manner that makes bypassing the sample line and probe, in an attempt to falsely pass a leak check, very difficult. Separate regulators shall be used for each cylinder necessary to perform a gas calibration. Regulators

shall be compatible with the gases of interest.

(22) System Leak Check. The analyzer shall require that a leak check be successfully passed on the same frequency as the gas calibration. The analyzer shall not allow an error of more than three percent (3%) of reading using midrange span gas to perform the leak check.

(23) Integral Span Gas.

(A) Upon initial delivery of the analyzer, the analyzer manufacturer shall supply the analyzer with all required calibration gases needed for proper operation. The gases supplied shall be obtained from a blender meeting the requirements of California's Bureau of Automotive Repair current specifications for approved gas blenders. The analyzer shall be equipped with a gas calibration port for the purposes of performing a probe to calibration port comparison.

(B) The analyzer shall be designed, in a manner approved by the state, to accommodate gas cylinders or other hardware necessary to perform the three (3)-day gas calibration. Mounting locations for brackets, necessary for gas cylinders, etc., shall provide adequate room for routine access, servicing and replacement of secured components. Brackets and other hardware shall be located so that analyzer stability and impact protection are considered in the design.

(C) The analyzer manufacturers shall design the connectors used with span gas cylinders so that cylinders containing different concentrations or compositions of gas cannot be switched. As an alternative, manufacturers may use the same connectors on all required cylinders if they display a message instructing the operator to properly connect the hoses to the gas calibration cylinders when they are not connected correctly. In addition, for this alternative, some type of reasonably permanent, prominent label or tag shall be used to readily identify which hose should be attached to which cylinder. Other alternatives may be presented to the state for consideration.

(24) Running Changes. Any changes to design characteristics or component specifications must be approved by state. It will be the instrument manufacturer's responsibility to confirm that the changes have no detrimental effect on analyzer performance.

(25) Probe. The analyzer manufacturer shall equip the analyzer with a sampling probe which meets the following criteria:

(A) Retention))The probe shall incorporate a positive means of retention to prevent it from slipping out of the tailpipe when in use;

(B) Hand Grip))A thermally-insulated, securely-attached hand grip must be provided on the probe in a manner that insures easy probe insertion using one (1) hand;

(C) Flexibility))Manufacturers shall supply two (2) types of removable probe tips with each analyzer sold. The probe and both probe tips shall meet the following criteria;

1. The probe shall be designed so that the tip extends sixteen inches (16") into the tailpipe;

2. The probe and probe tip should be designed so the average garage operator can easily remove and reinstall them without special tools;

3. A handle, made of thermally insulating materials, shall be attached to a rigid, reasonably noncrushable portion of tubing made of stainless steel or something equivalent, which can be removed easily from the sample line and reinstalled by the operator; and

4. The probe tip shall be shielded so that debris is not scooped up by the probe when it is inserted into the tailpipe;

(D) In addition, one (1) of the probe tips supplied with the analyzer shall be of the traditional style meeting the following specifications:

1. Flexible enough to extend into a one and one-half inch (1 1/2") diameter exhaust pipe having a three-inch (3") radius, forty-five degree (45°) bend; and

2. The flexible portion constructed so that it is sealed to prevent any sample dilution:

(E) Manufacturers shall also supply the analyzer with an essentially straight probe tip (no more than a fifteen degree (15°) bend) meeting the following specifications:

1. Made of either stainless steel or copper, three-sixteenths inch (3/16") outside diameter (od) solid-wall tubing, which is readily available; and

2. Designed so that the connector between the removable probe tip and the rigid portion of tubing is up inside the tailpipe at least three inches (3") to reduce the effects of any leak that might occur;

(F) The probe tip shall be designed so that the average garage operator can remove and reinstall it without special tools;

(G) Serviceability)) For the purposes of economical replacement, the flexible portion of the probe assembly must be designed so it can be replaced. The probes supplied shall be readily available;

(H) Materials)) The probe shall be made of materials that will withstand exhaust temperatures up to seven hundred degrees Fahrenheit (700°F). Use of dissimilar metals with thermal expansion factors of more than five percent (5%) shall not be used in either the construction of probes or connectors:

(I) Audit Gas Introduction)) Probes shall be designed to allow, or supplied with an adaptor allowing, the introduction of audit gas from a one-half inch (1/2") inside diameter flexible hose. The probe tip or the adaptor shall be sized to provide a tight fit so that dilution cannot occur at the probe/hose connection; and

(J) Probe Cap)) A probe tip cap suitable for performing a system leak check shall be provided if the vacuum decay method of leak check is utilized. Otherwise , whatever hoses and connectors are necessary shall be provided to allow the operator to perform the leak check.

(26) Hang-up Check. Activation of the emission measurements mode of the MAS shall be prevented unless a successful hang-up check has been performed immediately prior to the test sequence. Hang-up shall not exceed twenty parts per million (20 ppm) hexane prior to testing. A unit with a clean sample system shall have a hydrocarbon (HC) hang-up time of no more than one hundred-twenty (120) seconds. If the hydrocarbon HC hangup does not drop below twenty parts per million (20 ppm) within one hundred-fifty (150) seconds, the following message shall be displayed: Possible dirty filters or sample line. After each test, instructions shall appear on the display to direct the operator to remove the probe from the vehicle.

(27) Dilution.

(A) Dilution Requirement. The analyzer supplier shall demonstrate to the satisfaction of the state that the flow rate on the MAS unit shall not cause more than ten percent (10%) dilution during sampling of the exhaust of a 1.6 liter engine at normal idle. Ten percent (10%) dilution is defined as a sample of ninety percent (90%) exhaust and ten percent (10%) ambient air.

(B) Dilution Procedure. The procedure for measuring flow rate dilution is as follows:

1. Set vehicle with 1.6 liter maximum engine displacement at factory-recommended idle speed, OEM configuration exhaust system, transmission in neutral, hood up (a blower to cool the engine may be used if needed). Set idle speed not to exceed nine hundred twenty (920) revolutions per minute (RPM). (Set for nine hundred (900) RPM with an upper tolerance of twenty (20) RPM.)

2. With a laboratory grade analyzer system, sample the exhaust at forty centimeters (40 cm) depth with a flow sample rate below three hundred twenty liters (320 lr.) per hour. Allow sufficient time for this test. Record all HC, CO and CO_2 readings. A chart recorder may be used to detect the point of stable readings.

3. Set the MAS in the I/M mode and take HC, CO and CO_2 readings. Use the MAS I/M MODE readings for the computations in paragraph (27)(B)5.

4. Repeat paragraph (27)(B)2.

5. If the difference of the readings between paragraphs (27)(B)2. and (27)(B)4. exceed five percent (5%) of the average of paragraphs (27)(B)2. and 4., repeat paragraphs (27)(B)2. and 4., otherwise average paragraphs (27)(B)2. and 4., and compare with paragraph (27)(B)1. If paragraph (27)(B)1. is within ten percent (10%) of the average of paragraphs (27)(B)2. and 4., then the equipment meets dilution specifications.

(28) Barometric Pressure Compensation. Barometric pressure compensation shall be provided. Compensation shall be made for elevations up to six thousand feet (6000') (above mean sea level). At a given altitude and temperature, errors due to barometric pressure changes of plus or minus two inches of mercury (±2 in. Hg) will not exceed the accuracy limits specified

in this chapter. Manufacturers shall describe in writing how compensation will be accomplished. The method used shall be subject to approval by the state.

11 CSR 50-2.406

EPA Rulemakings

CFR: 40 C.F.R. 52.1320(c)(80)(i)(A)

FRM: 57 FR 46778 (10/13/92)

PRM: 57 FR 27959 (6/23/92)

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State Proposal: 15 MR 472 (3/16/90)

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Description: The EPA approved this new regulation which establishes requirements for the Missouri Analyzer System.

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Difference Between the State and EPA-Approved Regulation

None.